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Structuring Student Success: Incorporating a Genre-based Pedagogical Method to Improve a Strength of Materials Laboratory Manual

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Structuring Student Success: Incorporating a Genre-Based Pedagogical Method to Improve a Strength of Materials Laboratory Manual

In this research study the authors incorporated a pedagogical technique to improve a strength of materials lab manual. The conceptualization and subsequent development of a student friendly lab manual resource emerged from students' difficulty in understanding the following areas: introduction to experiment, procedures, calculations, and relevancy to class content. Based on a survey conducted before lab manual improvements and modifications, mechanical engineering students expressed high dissatisfaction with the written structure of the manual and felt they spent too much time understanding lab procedures, deciphering what equations to utilize to complete their analyzes, and completing the report. As such, the authors structured the new manual into three, step-by-step segments to improve the efficacy of the lab and decrease the amount of time spent in a one-hour credited lab: (1) Objective, (2) What to Include in Lab Report, and (3) Procedures and Calculation. The improved manual also included incorporating technical analyses that were related to the strength of materials course. As such, a survey was conducted with a cohort of 43 students to gauge responses and further understand their perspectives regarding the modified lab manual. Results indicate that the sections of the improved manual were clear and easy to follow, made an excellent job correlating the course and lab material, and reduced the time to complete the reports.

I. BACKGROUND AND MOTIVATION

Background

Currently, there are numerous teaching and pedagogical methods that target student engagement, comprehension, and scholarship abilities in engineering education. One of the most prominent is known as Project-based learning (PBL). PBL focuses on the application of knowledge rather than the acquisition of knowledge and its primary objective involves enhancing student comprehension by incorporating project-based instruction [13], [19], [20]. An alternative instructional method incorporated in engineering education is the implementation of visual cueing, which according to researchers, is verified to increase retention rates in less time than uncued visualization [1], [9], [12], [21]. Koning *et al.*, for instance, reported that students elevated their academic performance when visual cueing was implemented as evidenced by higher scores and transfer tests [4], [5], [6], [7]. Decades of research have further posited that classroom environment has a considerable impact on student learning, engagement, and success. Walberg and Boy et al., for instance, reported that educational productivity is dependent on the psychosocial aspect of the classroom [3], [15], [16], [17]. Furthermore, Marquez and Garcia developed the ECNQ model (e.g., acronym for Engage, Communicate, Names, Questions) as a practical and dynamic framework to engage engineering students and disrupt traditional normalized, ineffective teaching practices that limit and/or stifle student participation [11].

However, pedagogical methods not only include verbal and visual strategies, they also include written strategies that are based on rhetorical structure and linguistic choices. Well-structured and coherent documents are necessary to effectively communicate a specific message and facilitate student comprehension, scholarship ability, and retention rates. Without coherency, the reader will find difficulty understanding the objective of a document and completing specific requirements.

Motivation and Purpose of Study

The motivation and purpose of this study was to incorporate writing pedagogy to revise a strength of materials laboratory manual. Three factors propelled and informed the decision: 1) grade-assessment on specific lab experiments, 2) excessive amount of inquiries regarding technical content and learning outcomes of the manual, and 3) results of post-lab survey. Regarding survey results, a total of 64 mechanical engineering students (e.g., sophomores and juniors) participated in an open-ended questionnaire in an effort to provide detailed information regarding the issues associated with the logistical structure of the lab, which procures a total of eight experiments: 1) electrical strain gage, 2) torsion test, 3) tensile test, 4) deflection of beams, 5) compression test, 6) plate-with-hole, 7) strain gage rosette, and 8) beam resonance. The survey question and open-ended responses are included subsequently.

Pre-Survey Question: Are there further changes to the logistical structure of the class that you can envision that would continue to improve it?

Open-ended Responses

"Associate a lab with a section in the textbook so it can serve as more theoretical context."

"The lab reports often took more than four hours to complete."

"Students need to do more preparation and get to understand how machines work during the lab, rather than the TAs handling everything."

"I think the actual lab reports are confusing and not helpful."

"My biggest concern was that many of the lab reports were disorganized and unclear on what was being asked of us to do with our given data."

"I found the fact that the majority of labs requiring only 20 minutes of class time and then 4-5 hours of work on the actual report to be annoying."

"I would like to see the lab manual updated."

"If lab manuals were clearer, especially for the more advanced subjects that would help a lot."

"Remove information from the lab manual that is not necessary."

"Often, labs were difficult to complete because the lab manual was only partially informative on how to calculate certain things when we had not learned either the math or the theories in class."

"Lab reports were very vague in terms of specific instructions."

"I think drafting a more specific lab manual with less types will fix the problem"

"I think there were some confusion elements to the lab reports since the instructions didn't always seem clear to me."

"I was very confused about the material and what the lab was asking me to do."

According to survey results, high dissatisfaction was expressed with the written structure of the manual, particularly, in understanding lab procedures for various experiments, deciphering which equations to utilize for calculations, and correlating theoretical content between course and laboratory. In general, four major concerns were repeatedly noted about potential changes that would improve the laboratory experience, which motivated the instructor to reassess the effectiveness of the manual and subsequently make modifications to improve its overall efficacy.

The first concern related to specific theoretical content on the lab manual that was unrelated with the strength of materials course, which most mechanical engineering students took in conjunction with the laboratory. As such, it became difficult to interpret and analyze data, or even complete weekly reports, without the guidance of a teaching assistant (TA) or lab instructor. The beam resonance experiment, for instance, included vibrations analysis, while plate-with-hole experiment included finite element analysis, which are types of analyses covered in senior level courses.

The second concern on the open-ended responses was associated with the lab manual being compromised of a single, long document that contained excessive, confusing, unclear, and/or vague information. Students, for example, could not precisely identify which procedures to follow during specific experiments, which equations or calculations to implement for their analyses, and the data or information required to include in the weekly report. As a result, excessive amount of inquiries circulated during office hours.

Pre-survey responses additionally revealed an excessive amount of time dedicated to complete weekly reports. This concern was outlined for two reasons. The primary reason related to the lab being established as a one-credit hour course, and students felt it could largely be simplified to accommodate such requirement. Second, the need of deciphering equations for calculations, trying to acquaint with unfamiliar theory, and gauging the information for each report substantially increased the completion time.

The last major concern was not associated with the written structure of the manual itself, but rather linked to the lack of student participation in various lab experiments. From a general sense, the teaching assistant (TA) conducted experiments in which student involvement was negligible, or limited to observing and recording data. It was noted that increasing student participation would have largely contributed to the overall success of the lab and the comprehension of various technical content.

Research Question

To address these four concerns and the need to reduce the number of questions regarding technical content in the lab manual, the authors found it necessary to revise its written structure. As such, the following research question was delineated:

Q: How can the lab manual be revised such that it satisfies the following criteria:?

1. Easy to follow and understand
    a. Objective, Procedures, and Calculations
2. Correlates class and laboratory theory
3. Informs the user of data/information needed for weekly report
4. Completion time of lab report is minimized

Adopted Pedagogical Method

For the attempted solution, the authors employed a genre-based pedagogical method to develop a well-structured lab manual that was user friendly and thus increase the overall student learning experience. Such pedagogical method is associated with writing instruction and is rooted on the principle that writing is about deciding how to effectively communicate a message to a given audience [2], [8], [10], [14]. As such, genre pedagogy helps students identify the structural components of a document, so they are able to make informed choices consequently [2], [8], [10], [14], [18].

Given the concerns on the pre-survey, it is concluded that the written format of the lab manual is deficient and does not effectively communicate the necessary outcomes and requirements of each experiment. As such, it was problematic to determine the objective of each experiment, follow procedures, and interpret equations. According to Luzon, rhetorical structure and linguistic choice are essential components in written communication [10]. Thus, it is imperative that the revised manual is formatted in such way that students are able to understand the objective of each lab, follow well-written procedures in order to successfully carry out the experiment, understand data and calculations necessary for weekly reports, and correlate class and lab manual theory.

In this regard, it was determined to incorporate a manual in which its corresponding sections (e.g., objective, procedures, etc.) would each be formatted as a hierarchical list. This pedagogical format is suited to structure the revised manual in such manner that it facilitates the overall comprehension of experiments, sections in the manual, and enable students to make informed choices. With each section being structured hierarchically, the authors target to minimize confusion about procedures, calculations, and the data required to include in the weekly reports.

II. PROPOSED WORK

According to the authors, the revised lab manual would be structured with the following sections: 1) objective of the experiment, 2) procedures, 3) calculations, and 4) what data and information is needed for the weekly report (Table 1). Revision of the manual initiated by dividing the single, long document into eight individual manuscripts for each lab experiment. The objective was to eliminate the need of scrolling through an excessively large document, but rather have separate manuals for each individual experiment.

Table 1. Sections of Improvement for Revised Manual

Revised Manual Sections	Format Additions
1. Objective of experiment	Explicitly mention objective (brief)
2. Procedures	Procedures as hierarchical list
3. Calculations	Remove derivations, give step-by-step format
4. Data/Results needed for weekly report	Explicitly mention requirements

For the first section of improvement (e.g., objective of experiment), it was decided to explicitly mention the objective of the experiment in no more than four sentences. The intention was to keep the introduction as simple and concise as possible and eliminate technical jargon that tends to create confusion amongst the readers who are not familiar with specific technical content. For instance, Figure 1 displays the objective for the Torsion Test experiment, which conveys in two sentences that the intention is to 'understand how a steel, circular bar, loaded under torsion, behaves until failure.'

For the second section of improvement, the preceding lab manual mostly contained experimental procedures in paragraph format, as shown in Figure 2, which made it difficult for students to follow and understand. Thus, the authors decided to reformat the procedures in a numbering, hierarchical scheme such that each step would be followed accordingly (Figure 3). This modification eliminated the need of having to search in multiple paragraphs for necessary information and deciding what to implement. In addition, the revised manual specified exactly the type of table(s) needed for recording experimental data. This allowed students to include the corresponding tables that were expected on weekly reports, and not worry about point deduction.

For the third section of improvement (e.g., calculations section), the authors decided to remove technical calculations not associated with the strength of materials course, such as finite element and vibrations analyses, and incorporate pertinent assessments. However, all calculations were implemented in a step-by-step, hierarchical format, without any derivations, to avoid skimming through various pages before collecting the necessary equations (Figure 3). The notion behind this format was to reduce the amount of time taken to complete weekly reports and avoid unnecessary derivations which are generally covered in the strength of materials course.

I. Objective

The objective of this experiment is to understand how a steel circular bar, loaded under torsion, behaves until failure. Throughout the process the student will record torque and twist angle measurements for the Elastic region of the bar, its Yield point, and Plastic region.

II. What to include in the Final Report?

Section: Observed Data:

For the Observed Data section in the Report, include the following:

1. Table that contains the physical dimensions of the steel bar
2. Table that includes Torque and Twist angle values.

* The details of this data are found on the *Lab Procedure and Calculations* section.

Section: Calculated Results/Graphs:

For the Calculated Results section in the Report, include the following:

1. Maximum Twist value
2. Torque at Yield Point (from experiment)
3. Plot of Torque versus Twist
4. Maximum Shear Stress
5. Maximum Shear Strain
6. Shear Stress at Yield Point
7. Plot of Shear Stress versus Shear Strain
8. Shear Modulus calculation
9. Modulus of resilience
10. Modulus of rupture

The details of this data are found on the *Lab Procedures and Calculations* section.

Section: Discussion and Questions:

Answer the following questions:

1. How might the speed of the test affect the results?
2. How accurately is the yield point determined?
3. For steel, Poisson's ratio is approximately equal to 0.3. Given this information, compute the Young's modulus of the material you tested. Is this value in agreement with other reported values for the Young's modulus of steel?

Figure 1. Example of Revised Manual of Section I and Section II

Experiment 7

Plate with a Hole

4. Object

The object of this experiment is to gain an understanding of distributions of stress and strain, symmetry arguments, dimensional analysis and experimental stress analysis.

5. Procedure

A 11.5 inch by 5.75 inch by 0.257 inch aluminum plate with a central hole 1.25 inches in diameter has already been prepared and 10 strain gauges in different orientations have been mounted on this plate. Follow the instructions of the lab assistant and take strain readings from each of the gages at a few different levels of applied load.

6. Background

It may or may not be clear to you by now that generally the states of stress and strain in a structure are not uniform, but rather depend on position in the body. One example of a non-uniform stress distribution is that which occurs during the bending of a beam. By now you should all be familiar with the expression

$$\sigma = \frac{M(x)y}{I} \qquad (7.1)$$

where σ is the axial stress in the beam, $M(x)$ is the internal moment that the beam is supporting at the location x along the length of the beam, y is the distance above the neutral axis of the cross section of the beam and I is the moment of inertia of the cross sectional area of the beam.

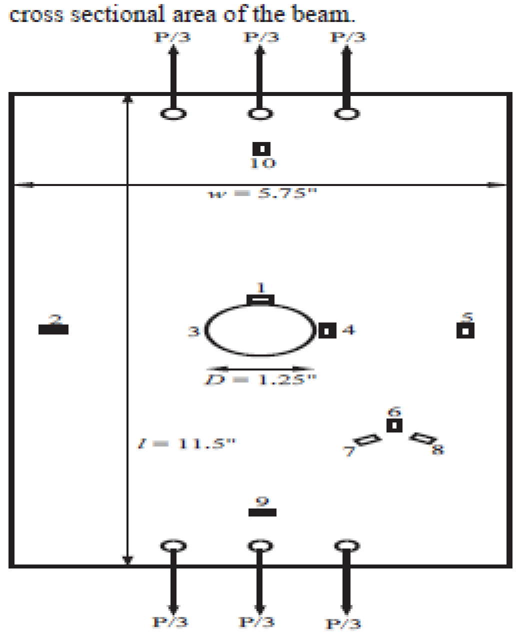

Figure 1. The plate with a hole and gage locations. The loading is *approximated* as three equal forces acting at the bolt holes.

Figure 2. Example of Procedure of Previous Lab Manual

For the last section of improvement, it was decided to explicitly state which data and information would be incorporated for the weekly report as the previous lab manual vaguely delineated, or even excluded, specific instructions. Such data and information generally included tables, figures, calculations, and discussion questions. To outline the information properly, a new section (Figure 4) was implemented in the revised manual called 'What to include in the Final Report.' Since the format of the weekly report includes five segments – introduction, procedure, observed data, calculated results/graphs, and discussion and questions – the new section was structured to include specific instructions for each segment.

III. Lab Procedure and Calculations

<u>PROCEDURES</u>

1. Verify that the following Equipment and Materials are available:

   a. Riehle 60,000 in-lb. torsion testing machine and accessories
   b. Cylindrical A36 steel bar (approximately 32” x 1”)
   c. Digital caliper and yardstick to measure bar

2. Prepare the **Test Bar**

   a. Begin by measuring the test bar and recording its dimensions. Don't forget to record the accuracy of all measurements. Create the following Table to insert your data:

Bar Dimensions (in)	
Gage Length	
Diameter	

   b. Use <u>chalk</u> and a <u>ruler</u> to mark a 10" *gage length* centered along the length of the bar. Also make marks two inches from each end to help ensure the bar is inserted into the torsion tester jaws at least that far.

   c. Mount the large gears of the twist meter on the bar. The set screws should be to the outside of the gears and determine the precise gage length.

   d. Be sure the gears are concentric and perpendicular to the bar and record the *gage length* and accuracy.

<u>CALCULATIONS</u>

1. Convert all Twist values from degrees to radians using the following equation:

$$\phi_{(rad)} = \phi_{(deg)} * \frac{2\pi\ rad}{360°}$$

2. Calculate the <u>Maximum Twist value</u> using the following equation:

$$\phi_{max} = \phi_{(\mathrm{deg})max} * \frac{2\pi\ rad}{360°} = \ radians$$

   where $\phi_{(\mathrm{deg})max}$ is the maximum angle in degrees from the Table in Step 5.

3. Plot the Torque-twist data.

   a. <u>Torque</u> should have units of $lb \cdot in$ and <u>Twist</u> should have units of radians.

4. Calculate the <u>Maximum Shear Stress</u> using the following equation:

$$\tau = \frac{T * R}{J}$$

   where J is the circular bar’s polar moment of inertia, $\frac{1}{2}\pi R^4$. This gives

$$\tau_{max} = \frac{T_{max} * R}{(\frac{\pi}{2} * R^4)} = \frac{2 * T_{max}}{\pi * R^3} = \ psi$$

Figure 3. Example of Revised Manual of Section III

*** What to include in the Final Report**

Section: Observed Data:

For the Observed Data section in the Report, include the following:

1. Table for the Measurements of Steel
2. Table for the Collected Load/Compression Data of each material
3. Photographs of each material after failure

* The details of this data are found on the *Lab Procedure and Calculations* section.

Section: Calculated Results:

For the Calculated Results section in the Report, include the following:

1. Compression-Load curve for each Material
2. Stress-Strain curve for Steel

* The details of this data are found on the *Lab Procedures and Calculations* section.

Section: Discussion and Questions:

Answer the following questions:

1. Consider the steel specimen. Does the final shape of the specimen seem reasonable for uniaxial stress? What other forces, aside from the overall compression, must exist on this specimen in order to create this final shape?
2. How does the behavior of steel in compression compare to the behavior in tension? Specifically, compare the shape of the stress-strain curves, Young's modulus, yield strength, and ultimate strength.
3. You have performed an experiment to determine the strains at different points in a plate with a central hole. One purpose of that experiment was to demonstrate that structural imperfections like holes tend to redistribute stresses in a structure or material. What types of imperfections do you find in the concrete specimen? Use these considerations to explain why it is possible to break something by putting it in compression.
4. In the study of the failure of materials it is always important to consider defects in the structure. The defects can range from small cracks and pores to hard particles. In all cases, defects have a tendency to redistribute stresses near the location of the defect. Soft defects of inclusions like a hole tend to push extra stress into the surrounding material, while hard defects like knots in wood tend to pull stress into the defect. How did the wood respond to loading and report if the wood did or did not respond as you expected? Did knots or wood grain significantly affect the failure?

Figure 4. Example of Revised Lab Manual – What to Include in the Final Report

III. METHODS AND ANALYSIS

The impetus for this research study was informed by three factors: 1) grade-assessment on specific lab experiments, 2) excessive amount of inquiries regarding technical content and learning outcomes of the manual, and 3) results of post-lab survey. The major component, nonetheless, was the survey in which mechanical engineering students expressed high dissatisfaction with the written structure of the strength of materials manual, particularly, in understanding lab procedures for various experiments, deciphering which equations to utilize for calculations, and correlating theoretical content between course and laboratory. This feedback, which was acquired during the Spring 2017 semester, was the genesis of this work and motivated the instructor to deliberately assess the relevance of the lab manual that students utilized and make necessary changes to better respond to students' learning needs.

The authors employed a qualitative case study research design to understand the perspectives of students regarding the modified lab manual. The sample selection consisted of 43 students enrolled simultaneously in the strength of materials course and the corresponding lab. Out of the 43 undergraduate students evaluated, none repeated the lab. Their classification ranged from sophomores to juniors. The primary method of data collection was a self-developed survey instrument that was administered after the 2019 spring semester. A total of six questions were constructed to assess the degree to which students found the revised manual useful, relevant, and responsive to their learning needs (Table 2).

Table 2. Administered Questions on Survey

Question 1: Tell us about the new structure of the lab manuals. The main sections included Objective, What to Include in Lab Report, and Procedures/Calculations. Were you able to properly identify everything you needed to calculate and include in your report?
Question 2: Were the Procedures in the lab manual written in a nice and clear manner?
Question 3: In previous years, groups contained up to 12 students, what do you think about the instructor creating small group sizes?
Question 4: Tell us about your experience operating certain machines.
Question 5: Tell us about your overall experience in this lab compared to what you've heard from previous students.
Question 6: Did the experiments/analyses relate to your strength of materials course?

Limitations of Study

The authors identified the following limitations of the study: small sample size; replicability of the study is limited to engineering students; lack of a comparison group to perform a T-Test for group differences; data collection was limited to surveys; study is limited to students enrolled in one engineering course; and lastly teaching assistants associated with the lab did not participate in the research study.

IV. RESULTS

Question 1: *Tell us about the new structure of the lab manuals. The main sections included Objective, What to Include in Lab Report, and Procedures/Calculations. Were you able to properly identify everything you needed to calculate and include in your report?*

Students noted that the new structure of the lab manual, which incorporated (1) Objective, (2) What to Include in Lab Report, and (3) Procedures and Calculation sections, met the research criteria that was of concern from the initial survey. For instance, students mentioned that the revised lab manual was clear and identified all the procedures and calculations needed to complete each experiment, while others acknowledged being detailed and organized. These comments reflect the effectivity of genre-based pedagogy, particularly when formatting each corresponding section as a hierarchical list. This pedagogical format facilitated the overall comprehension of experiments, sections in the manual, and enabled students to make informed choices.

> *"The lab reports were very clear on what was required of us and outlined things very well. I liked when it would say things like 'include this table of values' and so you knew to just replicate that table."*

> *"Overall, the way the instructions were laid out was really clear and helped us properly identify everything we needed."*

> *"The lab manual was an excellent guide for me. It was very clear, and I enjoyed the detail."*

> *"The structure of the lab was very explanatory. It was easy to identify everything I needed for the report."*

> *"I liked how organized and clear the lab report was in terms of expectations. I was easily able to tell what calculations/graphs the report wanted."*

Question 2: Were the Procedures in the lab manual written in a nice and clear manner?

With regards to the second question, the authors targeted the effectivity of implementing a hierarchical list in the Procedures section of the revised manual. Students noted that the corresponding section as well as the Calculations section, were greatly improved and helped minimize confusion and understand the overall objective of lab experiments. Various stated that the calculation instructions were straightforward and easy to follow, which indicated that the research criteria, 1a, postulated by the authors was met using genre-based pedagogy. In this regard, it was highlighted that the revision of the procedures section was beneficial as it outlined step-by-step what needed to be accomplished. This was particularly accommodating when students had to conduct experiments for which the theoretical aspect had not being covered in their current lecture. However, having each calculation and corresponding equations specified on the manual alleviated the need of having to derive expressions unfamiliar at the time.

> *"This was extremely helpful; I really enjoyed the clear format for equations and how we didn't have to decipher how to create the lab report."*

> *"The procedures were written in a clear manner that made the Procedure section easy to write."*

> *"The calculations were very straightforward, appreciated the sample calculations, very helpful."*

"The procedures were very straightforward so that you could get through the lab report even when the material had not been covered yet in lecture."

"The procedures were clear enough to complete the lab. The step by step calculations were very helpful in conducting my analysis and making sure I am completing the labs properly."

"Yes, it was very effective because it helped us organize the procedures and understand why we needed to do everything."

Question 3: In previous years, groups contained up to 12 students, what do you think about the instructor creating small group sizes?

In an effort to encourage participation during experimental procedures, the authors decided to reduce the number of students per group. According to survey feedback, this accommodation was taken positively as students felt group members took on different roles and responsibilities during the lab. As such, the productivity of the group increased as they depended on each other, which consequently led to an overall understanding of the material and lab itself.

"Smaller group sizes were good, we all got to participate."

"The small group sizes were way better as they required everyone to be somewhat involved and not zone out during the experiments."

"I definitely prefer small group sizes so everyone gets a chance to participate. Also, this ensures that everyone knows what is going on during the lab and everyone will pull their weight."

"I really liked the smaller group sizes, because I felt like I was actually contributing."

"The smaller group sizes made a large impact on my learning, as I was able to see the result of the experiment up close. With groups of three or four, every student had a role in the experiment and felt engaged."

"I like smaller groups because it is way more productive and there aren't as many distractions."

Question 4: Tell us about your experience operating certain machines.

Given the [pre-survey] feedback regarding the lack of student participation during experiments, the authors decided to organize students in teams of four and convey to the TA's the need for involvement. According to the [post-survey] open-ended responses, students who operated the equipment were able to understand concepts correlated with their coursework. Others stated being able to appreciate how ‘loads’ were applied to various materials, which is difficult to conceptualize from textbook problems. Being able to operate the machinery additionally made the lab experience more enjoyable and engaging rather than observing the TA conduct experiments in which student involvement was negligible, or limited to recording data. Others stated being more alert during experimentation when operating machines. However, a student pointed out not feeling comfortable operating machinery and equipment, but still felt engaged during the lab.

> *“Operating the machines was definitely important to me understanding the concepts.”*

> *“It was fun and engaging.”*

> *“I think it is perfect how it is now. Sometimes I did not feel comfortable conducting equipment but still felt engaged because my lab partners were conducting, which meant I got to read off numbers.”*

> *“Being able to operate the machinery helped me understand how exactly we were applying loads.”*

> *“Getting the hands-on experience is definitely more memorable and worth it.”*

> *“Physically operating certain machines was the best part of the lab and really helped me give intuition on how stresses are applied.”*

> *“Using the machines definitely helped me pay more attention.”*

Question 5: Tell us about your overall experience in this lab compared to what you’ve heard from previous students.

When asked to describe their overall experience with the revision of the manual, students overall felt a drastic improvement. A few mentioned that the new format reduced the amount of time necessary to complete the weekly report, particularly, since it contained every step for calculations. Though, the exact amount of time was not stated. These statements, nonetheless, indicate that the research criteria 4 postulated by the authors was met using genre-based pedagogy, particularly, a hierarchical list technique to structure the manual. In this regard, it was also acknowledged that the lab manual was easy to follow, straightforward, organized, and meaningful.

> *“Much better that what previous people told me.”*

> *“They said the lab reports took up to 10 hours, so definitely an improvement.”*

"We enjoyed it, they weren't super long and they were bearable to understand so that was good."

"From what I've heard from previous students, this year has improved greatly over previous year's versions of the class."

"Definitely a lot better, people were telling me I was lucky that the lab reports had been updated."

"I had heard that this lab was quite tough, and my experience was far from that. I found it clear, concise, informative, and exactly as much work as a 1-credit hour lab should be."

"I honestly hadn't heard much about this lab previously, but despite not having any prior expectations, my overall experience was very pleasant. The instruction was overall very simple to follow, the experiments were engaging and relevant, and I feel like the grading was fair."

"The class sounds better than it has been in the past. We got the idea of each lab without having to spend unnecessary timey trying to decipher the calculations."

"Going into this lab, I was somewhat nervous, as other students had told me that the lab reports were incredibly difficult. In particular, the deflection of beams and plate with hole experiments were incredibly difficult for students in previous years. My experience with this class was much different largely because this year's lab reports had step by step derivations that I could follow rather than starting from scratch. This simple addition had an incredibly positive effect on my experience in the lab."

"I've heard it was terrible because of the lab reports, but I think making them more straight forward was a good move because it makes the labs more manageable with still getting the information across."

"The overall experience in my class was great, and it is one of the most enjoyable labs."

"I've heard that it was a bit disorganized in previous years, but this year's lab was everything I expected a good lab to be: organized + straightforward. The redesigned worked."

"Way better than expected. Students before talked about the horrible 10-hour labs they had no idea how to do."

Question 6: Did the experiments/analyses relate to your strength of materials course?

Concerns on the pre-survey emphasized that most theoretical content on experiments was not correlated with the strength of materials course, which most mechanical engineering students took in conjunction with the laboratory. As such, it became difficult to interpret and analyze data, or even complete the weekly report within a reasonable time frame. However, when asked if the new manual incorporated analyses related to their class theory, students felt the revisions aligned well with their coursework.

> *"The correlation between class and the lab was good."*
>
> *"Yes. The labs were always related to the strength of materials course."*
>
> *"All of the equations used in the labs were derived in class."*
>
> *"The experiments incorporated a ton of stuff from the course, and it was cool to see the equations and formulas used in real life."*
>
> *"Most of the topics we covered in class where also covered in the labs. The only problem was that sometimes we covered the material in the lab before covering it in class. Though this made the lab confusing, the detailed explanations in the lab manuals helped me understand the overall concept."*

Since most students were concurrently enrolled in the lab and strength of materials class, a recurrent concern throughout the post-survey was having to complete specific lab experiments before covering the theory in class. It was noted, however, that the detailed explanations in the manuals alleviated the problem.

V. CONCLUSION

In this case study, the authors implemented a genre-based pedagogical technique that consisted of modifying an existing strength of materials lab manual to better respond to student learning needs. Such pedagogical method is associated with writing instruction and is rooted on the principle that writing is about deciding how to effectively communicate a message to a given audience. The rationale for this innovation was grounded in the frustrations and complexities experienced by engineering students. As such, a deliberate effort was made to reconceptualize the existing lab manual into a learner centered version that maintained academic rigor, increase student accessibility, and help remedy the frustrations expressed by students. Modifications made to the lab manual addressed four primary concerns expressed by students which were: 1) theoretical content on each experiment was not correlated with the strength of materials course; 2) excessive time to complete reports; 3) disorganization and excessive content; and 4) lack of student involvement.

For the attempted solution, the authors employed genre-based pedagogy to develop a well-structured lab manual that was user friendly and would increase the overall student learning experience. It was determined to incorporate a manual in which its corresponding sections would each be formatted as a hierarchical list. This pedagogical format was suited to structure the revised manual in such manner that it facilitated the overall comprehension of experiments, sections in the manual, and enable students to make informed choices. With each section being structured hierarchically, the authors targeted to minimize confusion about procedures, calculations, and the data required to include in the weekly reports.

Based on the findings, the students acknowledged that the structure and outline of the revised lab manual enhanced their understanding, minimized frustration, and reduced time to complete the assignments. Although, it is beyond the scope of the study, it can be assumed that the impacts of the revised manual will help generate other positive outcomes that will inform student learning moving forward. Moreover, it also underscores the needed to engage in best practices such as continuous refinement of course materials on the part of instructors to ensure high levels of student learning, engagement, and overall satisfaction.

It is noted, nonetheless, that the post-survey via student feedback is subjective, and might not reflect the extent to which students learned. The responses to question six in the post-survey, however, reflect that experiments and analyses of the lab related to the strength of materials course, but do not reveal specific learning outcomes. Future research will incorporate both control and test groups in order to initiate comparison analyses and reveal specific learning outcomes.

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